Response of Canola and Wheat to Amendment With Biochar Under Controlled Environment Conditions

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Keyword: Biochar, Crop yield, Fertilizer recovery

Abstract

Response of canola (*Brassica napus* Invigor 5030) and wheat (*Triticum aestivum* Prodigy) to biochar amendments was examined in a controlled environment experiment. A Brown Chernozem soil was amended with two types of biochar (wheat and willow biochar) at 1 and 2 t ha^{-1} alone and in combination with N and P fertilizer. Canola was grown in amended pots in controlled environmental conditions over a four week period. Parameters evaluated were germination and biomass yield, soil organic carbon, above ground nitrogen and phosphorus uptake and % recovery of applied N and P after 4 weeks of growth. The addition of biochar alone had limited impact on biomass yield (Fig 2, 3, 4 and 5). Addition of fertilizer, especially N, significantly ($p<0.05$) increased canola yield. The calculated plant recovery of applied fertilizer was often increased by biochar addition at the 1 T/ha rate.

Introduction

Biochar is a carbonaceous material produced by the combustion of organic material under O_2 limited conditions (pyrolysis). It can sequester carbon (C) and maintain or improve soil functions. Low biodegradability, high porosity and high surface area of biochar can affect soil fertility by enhancing available soil N and P. It can increase soil pH, CEC, retain nutrients which can benefit yield in highly weathered soils (Chan et. al 2007). But little or no information on how different crops respond when biochar added as amendments to Saskatchewan soils.

Objective and hypothesis

General:
To evaluate the effectiveness of two different biochars as soil amendments to improve soil conditions for crop growth, with emphasis on soil fertility impacts in Saskatchewan soils.

Hypothesis:
Biochars will improve nitrogen fertilizer recovery and use efficiency.

Materials and methodology

Growth Chamber Experiments

Experiment started: April, 2011

Soils: Two Soils from Contrasting Soil-Climatic Zones. A Brown Chernozem from Central Butte, Saskatchewan with low OM content (2%) and Black Chernozem from Conservation Learning Center (CLC) of Prince Albert, Saskatchewan with relatively higher OM (6%).

Biochars: Two sources. Wheat straw and Willow feedstock manufactured by fast pyrolysis with temperature above 400°C. Chars produced by Sask Research Council.

Crops: Canola (*Brassica napus* Invigor 5030) followed by Wheat (*Triticum aestivum* Prodigy) in rotation.

Growing Period: 4 weeks/each crop.

Treatments: (Table 1)

Table 1. Experimental set up for each biochar type in combination with nitrogen (N) and phosphorus (P) fertilizer.

Treatment	Soil types	Biochar (t/ha)	Crop type	Fertilizer rate (kg/ha)	Replicates	# pots
Control	Brown	0	Canola-Wheat	0N+0P; 0N+25P; 50N+0P; 100N+0P; 50N+25P; 100N+25P	4	24
	Black	0	Canola-Wheat		4	24
Biochar	Brown	1	Canola-Wheat		4	24
	Black	1	Canola-Wheat		4	24
Biochar	Brown	2	Canola-Wheat		4	24
	Black	2	Canola-Wheat		4	24
Total Pots (Brown 72 & Black 72)						144

Soil and Plant Sampling:

Soil : After harvest of canola and final harvesting of wheat.
Plants: canola-3 plants/pot and wheat-5 plants/pot.
Analysis of basic Soil Characteristics: Soil texture, pH, EC, and SOC. In addition, plant N and P concentration, soil extractable nitrate, phosphate and sulfate.
Statistical Analysis: Pot was arranged in growth chamber following Completely Randomized Design. Statistical comparisons conducted using LSD ($p \leq 0.05$).

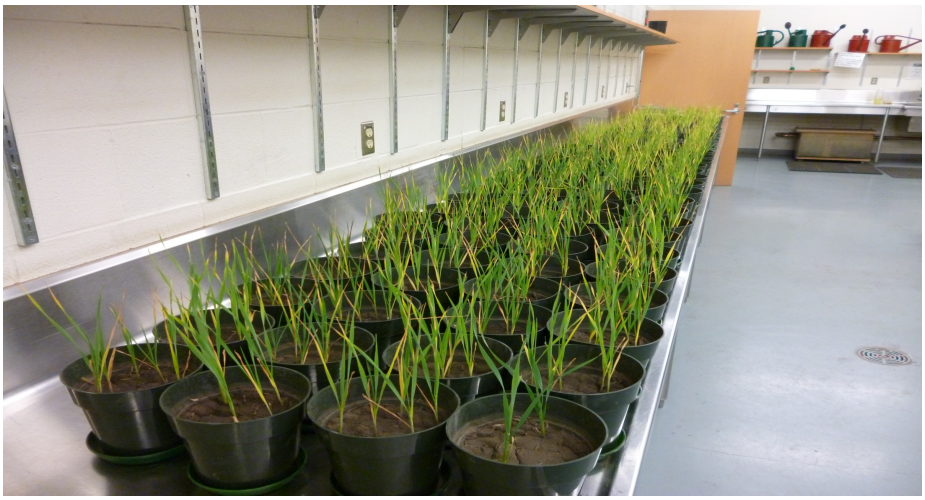

Figure 1: Wheat grown on Wheat straw biochar amended Black Chernozem soil.

Results and discussion

Effects of Biochar on Canola Yield:

The addition of biochar alone had limited impact on biomass yield (Fig 2, 3, 4 and 5). Addition of fertilizer, especially N, significantly ($p<0.05$) increased canola yield. The combination of the biochars with fertilizer tended to enhance canola yield slightly over fertilizer alone at the low rate of biochar amendment on the Black soil. Wheat grown in rotation showed a trend toward a negative effect of biochar, possibly because of greater utilization of N and P by the preceding canola crop in the presence of biochar.

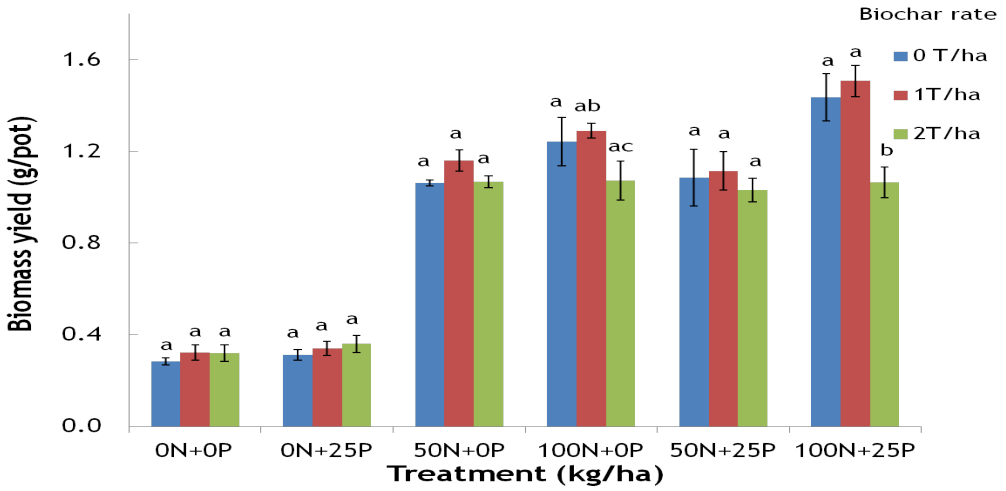

Figure 2: Canola Biomass Yield (g/pot) on Wheat straw biochar amended Brown Chernozem soil .

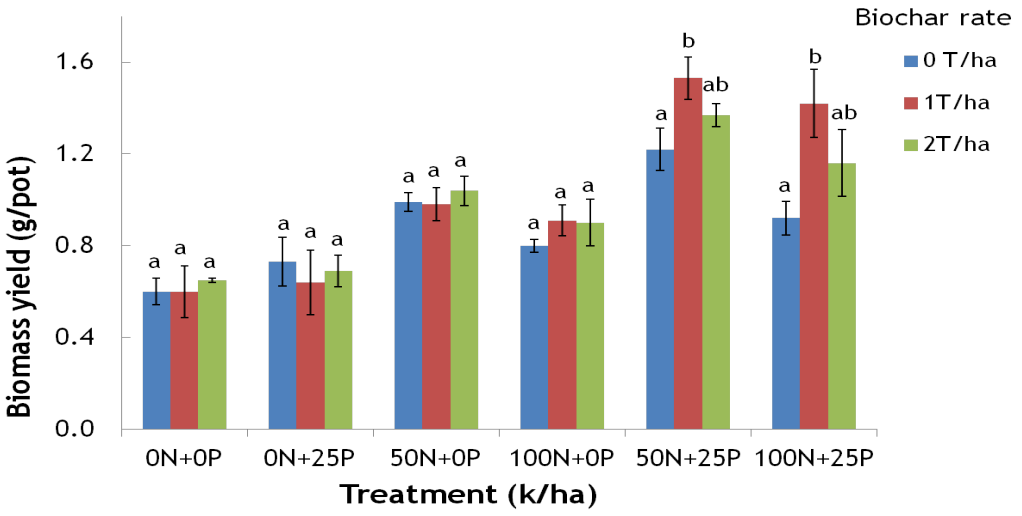

Figure 3: Canola Biomass Yield (g/pot) on Wheat straw biochar amended Black Chernozem soil.

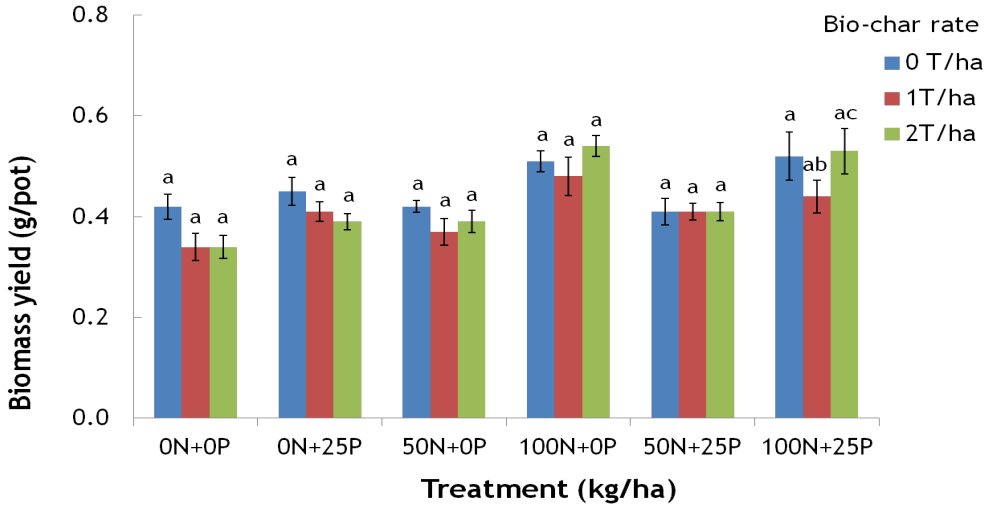

Figure 4: Wheat Biomass Yield (g/pot) on Wheat straw biochar amended Brown Chernozem soil .

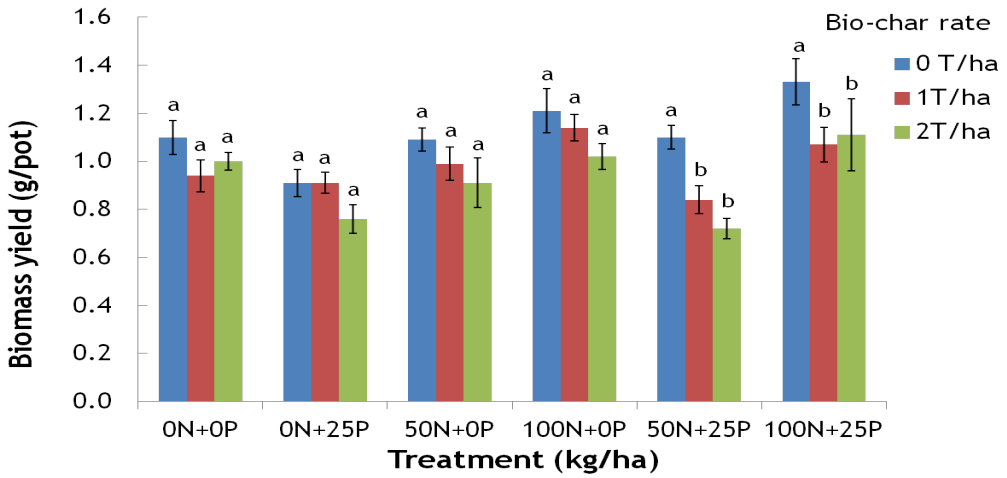

Figure 5: Wheat Biomass Yield (g/pot) on Wheat straw biochar amended Black Chernozem soil.

** Means in columns for a fertilizer treatment followed by a different letter are significantly different at P<0.05.

Effects of Biochar on Fertilizer Recovery:

The calculated plant recovery of applied fertilizer was often increased by biochar addition at the 1 T/ha rate (Tables 2 and 3). The 1 T/ha biochar rate was more effective than the 2T/ha rate for both biochars. Effects of the two biochars on the Brown and Black Chernozem soils were similar.

Table 2: Percentage of applied fertilizer N recovered by canola and wheat.

Biochar	Wheat Straw biochar						Willow biochar					
Fertilizer rate	Brown Soil			Black Soil			Brown Soil			Black Soil		
	(Biochar T/ha)						(Biochar T/ha)					
	0	1	2	0	1	2	0	1	2	0	1	2
50N+0P	24	30	26	35	36	30	20	20	20	31	32	25
100N+0P	33	42	37	35	43	36	25	27	22	30	30	31
50N+25P	22	20	17	43	37	26	14	14	12	28	38	24
100N+25P	40	43	34	38	48	37	21	22	28	33	37	40

Table 3: Percentage of applied fertilizer P recovered by canola and wheat.

Biochar	Wheat Straw biochar						Willow biochar					
Fertilizer rate	Brown			Black			Brown			Black		
	(Biochar T/ha)						(Biochar T/ha)					
	0	1	2	0	1	2	0	1	2	0	1	2
0N+25P	3	5	4	7	6	5	5	6	4	7	3	5
50N+25P	11	10	11	11	11	9	6	5	6	6	7	6
100N+25P	16	17	15	12	14	14	5	7	14	10	8	10

Conclusion

Biochar in combination with fertilizer tended to enhance fertilizer recovery and affected plant yield slightly compared to fertilizer alone. The two biochar types had similar effects on plant growth and nutrient recovery on the two soils. More biochar sources will be included in a future field evaluation.

References

Chan, K.Y., Van Zwieten, L., Meszaros, I.A., Downie, A., and Joseph, S. 2007. Agronomic values of greenwaste biochar as a soil amendment. Australian Journal of Soil Research, 45, 629–634.

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